A DICHOTOMOUS KEY FOR FIELD IDENTIFICATION OF THE ORDERS OF INDIAN DIPLOPODA[1]

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(*With ten text-figures*)

Key words: Taxonomy, Diplopoda, Identification, Dichotomous Key, Orders, Families

This paper is intended as a guide for identification of Indian diplopods, at least to their Orders. The Indian diplopod fauna, so far known, consists of 11 orders, 20 families, and 100-120 genera, with approximately 500 species. Many more might be unlisted because of lack of expertise. A key for identification has been provided.

INTRODUCTION

Diplopods are some of the most frequent fauna of Tropical, Subtropical, Temperate Forest floors and other ecosystems. Despite their frequent occurrence, they have evinced very little interest among zoologists, even less among systematists, especially in India. They are the most neglected group compared to the Insecta and Arachnida, and are scarcely studied, perhaps due to lack of expertise.

Hoffman (1979) reported Diplopoda of the world, comprising 10,000 species under 15 orders, 115 families and over 1,700 genera. Studies on Indian diplopods date back to the pre-independence era, and since then have not been updated. Attems (1936) reported 290 species from Indian Territory. Carl (1941) added 15 species. In the last 3 decades, a few sporadic reports that appeared were those of Demange (1961, 1969, 1970, 1975, 1977a, b, 1983 and 1989), Jeekel (1968 and 1980), Hoffman (1977), Hoffman and Burkhalter (1978), Golovatch (1983, 1992 and 1993), and Golovatch and Martens (1996). The Indian diplopod fauna known today consists of 11 orders, 20 families and about 100-120 genera with around 500 species. A note on their general characters, collection and preservation has already been published elsewhere (Bano 1999).

During the last 3 years, the author, while working on the systematics of Indian diplopod families, Harpagophoridae and Paradoxosomatidae felt the need to update the key, and has now attempted to bring out a concise and illustrated key for their identification. A brief account of the characters and distribution is added.

CLASS DIPLOPODA

Characters: Diplopods are commonly called millipedes, meaning 'thousand legs', although no individual of this group bears a thousand legs, their many legs and wave-like motion has given them the name millipede.

Diplopods are defined as many-segmented, many-legged, terrestrial, tracheate, mandibulate, antennate, progoneate, oviparous and anamorphic arthropods. They are long, cylindrical or sub-cylindrical, excepting a few dorsoventrally flattened forms (Polydesmida and Chodeumatida). Body measures from 2.0 mm (Polyxenida) up to 200 mm in length (Spirostreptida, Spirobolida and Julida). The outer body covering is a hard chitinous, shiny and beautifully coloured exoskeleton, except in

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Polyxenida. The body consists of an anterior head capsule, bearing one pair of 8-jointed antennae. Just behind the antennae, at the sides or more rarely on the middle of the forehead, are a group of simple eyes or ocelli. Ocelli may be numerous or reduced to 5, 3 or even 1 on each side, or completely absent as in the case of Polydesmida, Siphonophorida and in some cave-dwelling forms. Between the eyes and the antennae is a small sensory pit. The frontal margin of the head is the labrum or the clypeus, which is notched at the middle, usually bearing three teeth. Underneath are a pair of mandibles carrying powerful cutting edges, at the base of which are placed a pair of maxillae which are fused, forming a plate called gnathochilarium acting as a labium, or floor of the buccal cavity. Diplopoda is unique among arthropods in possessing a gnathochilarium.

The head is followed by a long, segmented trunk. The segment immediate to the head capsule is the colium, large, devoid of legs and with paired sternites. Following this are three segments bearing three pairs of legs. The remaining body segments are made up of two somites each (diplosomite), the anterior prozonite and the posterior metazonite. The diplosomites carry two pairs of legs. The last segment lacks legs and is called the telson or the pygidium. The telson ends in a long or short, sharp or blunt spine, bent upward, or downward, or straight. Most of the millipedes are equipped with defence glands, the repugnatorial glands or the ozadenes, opening through ozopores located laterally on the metazonites and distributed on most of the body segments, except a few anterior and tail segments. The secretions of these glands are odoriferous, highly volatile compounds of hydrogen cyanide, phenols, iodides, terpenoids, quinones and aldehydes, which act as a deterrent to other animals.

All the diplopods are progoneate; the genital ducts of both sexes open on ring iii. In males of spirostreptids, spirobolids, julids stemmiulids and polyzonids, the paired deferent canals open into a median penis or paired penes behind the second pair of legs. In glomerids, chordeumatids and polydesmids, the deferent canals perforate the coxae of the second pair of legs. In females of all orders, each oviduct opens separately into a vulva or cyphopod behind the second pair of legs. Each vulva consists of a bivalve bursa with an anterior opening covered by an operculum. Within the bursa is the apodermatic tube terminating with one or two ampullae, which function as seminal receptacles or spermathecae. Each vulva lies in a sac sunk into the lumen of the ring behind the second pair of legs. The sac and the vulva are everted during copulation.

Distribution: Diplopods are abundant in warm humid tropics and all temperate broad leaf forest regions of the world (Hoffman 1990). They occur from the snow line down to sea level, and some are cave and sand dune dwellers. They are primarily inhabitants of forest floors and the relic fauna is found to have established in plains, cultivated lands, grasslands, and gardens. Their distribution is contiguous; they are found in large aggregates, small numbers or in singles, crawling aimlessly on the verges of roads or in open fields and plain lands, or lying spirally coiled under litter or mineral soil. They are active on the surface during the monsoon after one or two showers (April to June and October to December).

Systematic and faunistic knowledge of Indian Diplopoda is poor, archaic and incomplete. The fauna reported so far is chiefly from the northern Himalayan regions and southern Peninsula. The majority of the Himalayan fauna is localized in distribution, restricted to certain altitudes, and very few species are widespread (Golovatch and Martens 1996). Among the diplopods, worldwide distribution is very rare. According to Attems (1936), the Indian diplopod fauna is largely endemic, and bears a close relationship to the

African, and to a certain extent to the Australian fauna. But the majority of the fauna is endemic and localized. Among the Harpagophoridae, the genus *Gonoplectus* is specially restricted to the northern Himalayan region, whereas the other genera such as *Harpurostreptus*, *Carlogonus*, *Gnomognathus*, *Organognathus*, *Ktenostreptus* and *Phyllogonostreptus* are largely of Peninsular India. Sphaerotherids are reported from both the regions, but are restricted to high altitudes. The millipedes of the Orders Chordeumatida, Julida and the genera of Family Furhamonodesmidae, Order Polydesmida, are reported only from Himalayan ranges, whereas the other three families of Polydesmida are reported from both the regions. Thus, diplopods exhibit biogeographic affinities.

Dichotomous key for the Orders of Class Diplopoda

1. Body wall membranous without sclerotisation. Body soft, consists of 11 segments with 13 pairs of legs, covered with tufts or clusters of setae or bristles. Males without copulatory organs (gonopods). Minute animals of 2-3 mm length. Found in dry places. Commonly called 'bristly' millipedes (Fig. 1) ..... Polyxenida.
Family: Polyxenidae
(1 species reported from Kashmir, 1 species reported from South India)

— Body wall sclerotised. Body hard, composed of 13 or more segments. Setae, if present, always single and simple, never in tufts or clusters. Adults with 17 or more pairs of legs. Tarsal claw simple and acute. At least one pair of legs modified into copulatory organs (gonopods) in males 2

2. Dorsal surface of body slightly convex. Adults with 13 or 22 segments. Segmental sclerites loosely attached (pentazoneate, Fig. 2a). No plural keels. Last pair of legs modified into copulatory organs 3

— Body flat or sub-cylindrical. Adults with 19 or more segments. Segmental sclerites completely fused to form a tight ring (monozoneate, Figs 2b, 2c and 2d) or attached with membranous joints. Paired legs on 7th segment modified into gonopods in males 5

3. Body composed of 13 segments. Head with a row of ocelli (eyes). Animals capable of rolling into tight balls or spheres. Males stridulate by rubbing last pair of legs with sides of last tergite 4

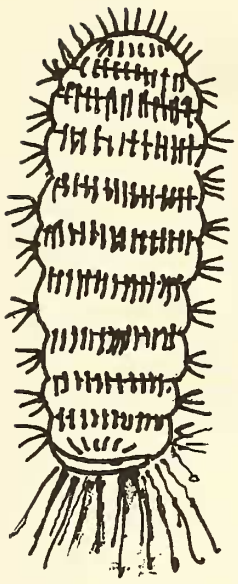
— Body composed of 22 segments. Head without ocelli. Animals not capable of rolling into a ball or sphere, males do not stridulate ..... Glomeridesmida
Family Glomeridesmidae
(2 species known from South India)

4. Animals large, up to 8 cm. Body surface smooth, grey to black in colour without any ornamentation, called 'giant pill millipedes' (Figs 3a and 3b) ..... Sphaerotheriida.
Families Sphaerotheriidae and Sphaeropoeidae
(More than 30 species reported from India)

— Animals small, up to 2 cm. The 2nd and 3rd body segments fused to form a broad plate (Fig. 3c) laterally, accommodates the lateral tip of the following terga during ball formation. Cuticle jet black, sometimes with brightly coloured spots ..... Glomerida
Family Glomeridae
(3 species reported from North India)

5. Body flattened, sub-cylindrical, with 19 segments. Segmental sclerites fused into a single solid ring, usually without traces of sutures (Fig. 2b). Ocelli always missing. Gonopod formed from only the anterior pair of legs of the 7th segment, posterior pair of legs absent (Fig. 4) ..... Polydesmida
Families Paradoxosomatidae, Fuhrmannodesmidae, Pyrgodesmidae and Cryptodesmidae
(More than 60 species known from India)

— Adults with 26 or more segments, not completely coalesced. Sterna and pleura joined by a membrane, or with a distinguishable suture (Figs 2b and 2c). Both pairs of legs of 7th segment modified into gonopods. If the gonopod is modified from a single pair of legs, the sterna not coalesced with pleuroterga, and the latter ornamented with longitudinal ridges (Figs 5b and 5c) 6



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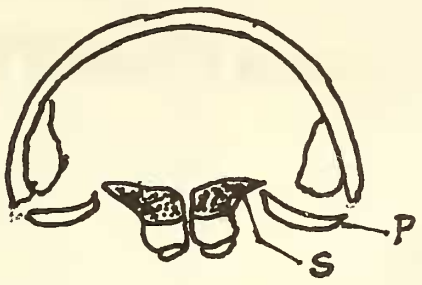

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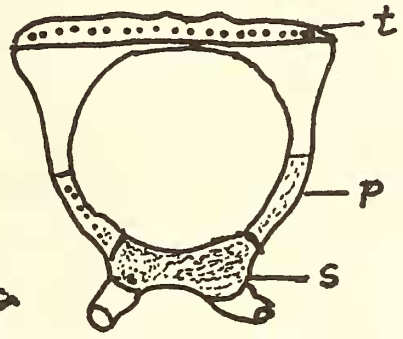

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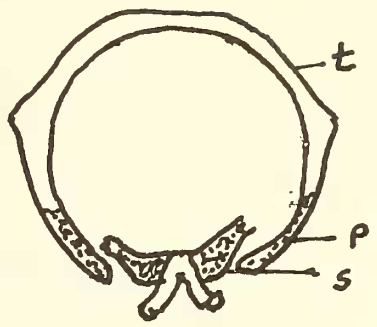

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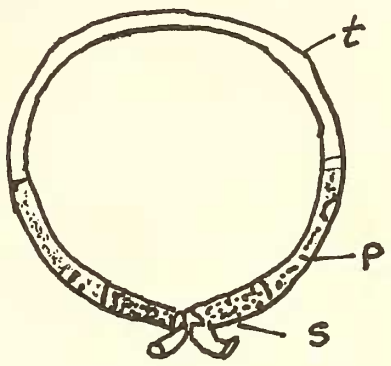

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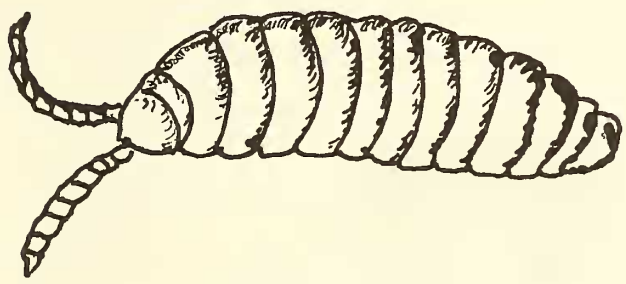

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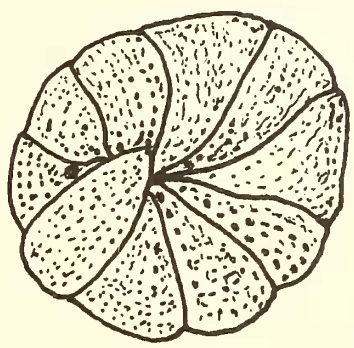

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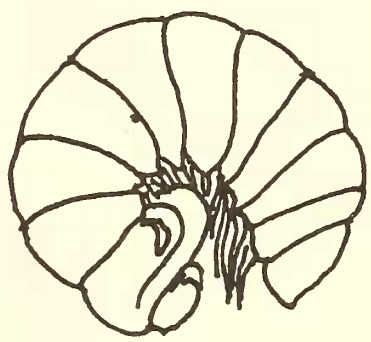


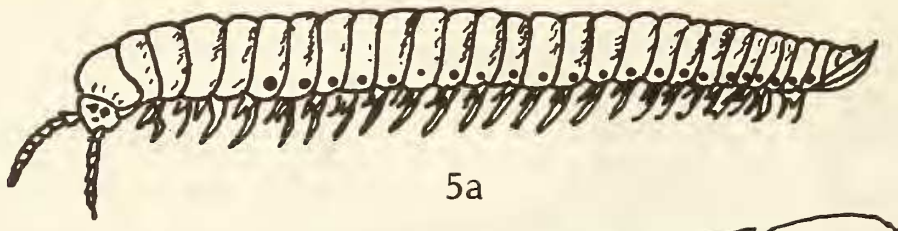
3c

Figs 1-4: 1. *Polyxenus* (Dorsal View), 2. Cross sections of segments of: a. Glomerid, b. Polydesmid, c. Chordeumatid, and d. Spirostreptid. (s: sternite; p: pleurites; t: tergites), 3. *Arthrosphaera* (Sphaerotheriida): a. extended animal, b. rolled into a ball, 3c. *Glomeris* (Glomerida) curled up, 4. *Anoplodesmes tanjoricus* (Polydesmida)

6. Head variable in form, usually as broad as the collum, without ocelli, anteriorly produced into a beak or rostrum. Body setose, thin and long. Large number of segments (180-190), with simple gonopods. Antennae straight, distal article enlarged. Article 5 with sensory pit (Fig. 6). Metaterga without longitudinal suture. Sterna and pleura flexibly articulated by connective tissue ..... Siphonophorida
Family Siphonophoridae (2 species from South India and 1 from North India)

— Head smooth, rounded, without beak or rostrum. Body straight, arched or cylindrical, with 26 or more segments. Antennae without sensory pits. Sterna, pleura and terga completely coalesced into rigid cylindrical rings 7

7. Body with 26-30 segments in adults. Arched or sub-cylindrical. Sternites not coalesced (Fig 2c). Ozopores absent. Ninth and tenth



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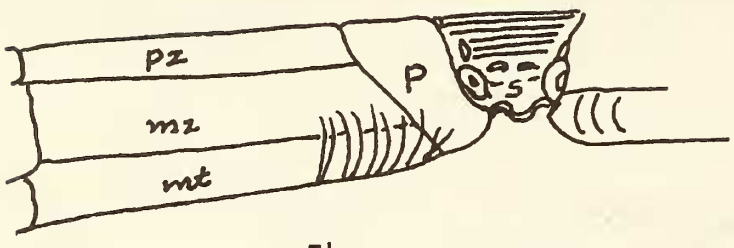

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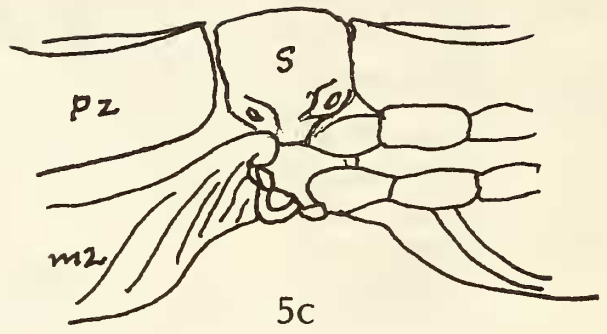

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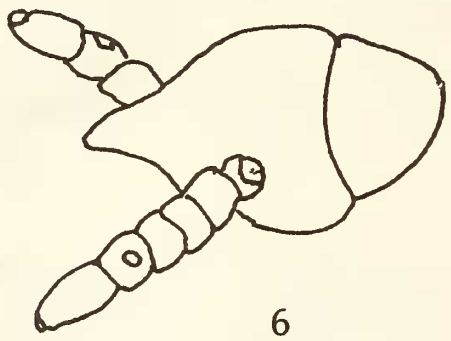

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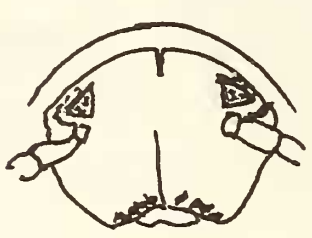

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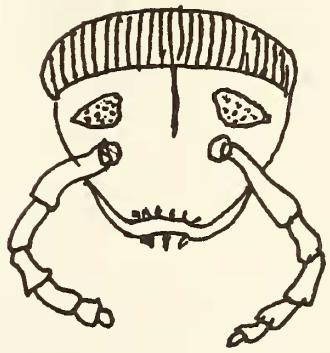

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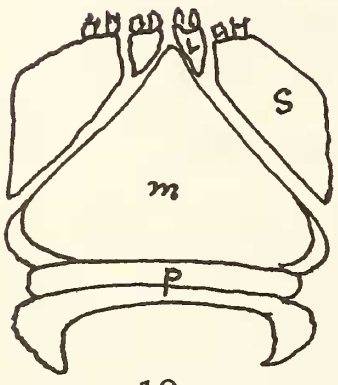

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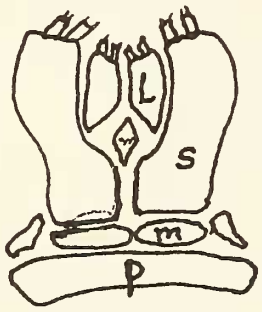

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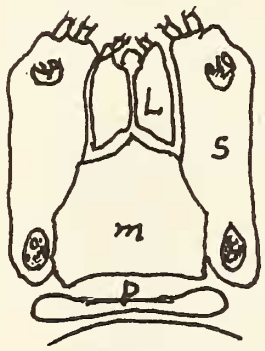

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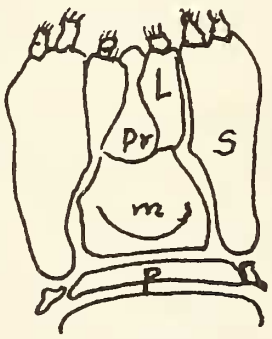

10d

Figs 5-10: 5a. *Phyllogonostreptus nigrolabiatus* (Spirostreptida), 5b. Body segment (ventral view) spirobolid, c. Body segment (ventral view) Spirostreptid, 6. Head with collum (lateral view) Siphonophorid, 7. Head with a few segments (lateral view) Stemmiulid, 8. Head (front view) with clypeal suture Spirobolid, 9. Head (front view) with occipital suture Spirostreptid, 10. Gnathochilarium: a. spirobolid, b. julid, c. spirostreptid, d. cambalid, (s. stipes, l. linguales, m. mentum, p. prementum)

pairs of legs with coxal sacs in males. Metaterga with 3+3 macrochetae and with external swellings or keels. Epiproct with spinnerets ..... Chordeumatida

Family Cleidogonidae and Kashmireumatidae (2 species known from North India)

— Body with more than 30 segments, cylindrical. Metaterga without keels and macrochaetae. Epiproct without spinnerets, but with or without a simple spine 8

8. Head with one or two large ocelli on each side (Fig. 7). Pleurites and tergites fused. Metatergal suture prominent .... Stemmiulida

Family Stemmiulidae (3 species known from South India)

— Head with numerous ocelli in ocular field, or ocellaria. Ocular field triangular / reniform or oval. Segmental sclerites fused into a complete ring 9

9. Ocular field rounded or oval. No occipital suture between them, but clypeal suture evident (Fig. 8). Pleural sclerites distinct (Fig. 5b). A single pair of legs up to 5th segment. Gnathochilarium with a broad mentum separating the bases of the stipes and lingulae from each other (Fig. 10a) ... . Spirobolida

Families Spirobolidae, Pachybolidae and Physobolidae (More than 30 species reported from South India)

— Ocular fields reniform or subtriangular, usually with a fine occipital suture between them (Fig. 9), clypeal suture absent. Pleural sclerites completely fused with the lower end of terga. No suture in between (Fig. 5c). Segment 4 without legs. Gnathochilarium variable 10

10. Large millipedes up to 15-20 cm in length, with up to 90 segments (Fig. 5a). Occipital suture evident. Pleural sclerites indistinct. 4th segment without legs. Male gonopods consist of both pairs of legs of 7th segment, anterior pair more active. Stipes of the gnathochilarium always widely separated by a large median mentum (Figs 10c and 10d) ..... Spirostreptida

Families Spirostreptidae, Harpagophoridae, Cambalidae (Fig. 10d) and Adiaphorostreptidae (More than 70 species known from India)

— Small cylindrical millipedes. Bases of the stipes of gnathochilarium broadly in contact medially. Small prominent sclerites, a promentum isolates the stipes from the linguales. Mentum, a transverse large plate (or 2 plates) present at the bases of the stipes (Fig. 10b) the male gonopods formed from both pairs of legs on the 7th segment..... ..... Julida

Family Julidae (1 species reported from North India)

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APPENDIX

FIELD IDENTIFICATION OF ORDERS OF CLASS DIPLOPODA

1. Body soft, with tufts of setae ..... Polyxenida
— Body hard, no tufts of setae 2
2. Adults at most with 13-22 body segments 3
— Adults with 26 or more body segments 6
3. Body flat. Adults with 20 segments. Segmental sclerites fused into a complete ring (monozoneate), tergites usually with lateral wings or keels ..... Polydesmida
— Body subcylindrical, each segment with a tergite, two pleurites and two coxosternites freely attached (pentazoneate); no lateral keels 4
4. Adults with 22 segments. Head without ocelli, animals unable to roll into a ball .... Glomeridesmida
— Adults with 13 segments. Head with a row of ocelli, animals roll into a ball 5
5. Large animals, grey to black in colour, without ornamentation (giant pill millipedes) .... Sphaerotheriida
— Small animals, jet black colour, some with bright coloured spots, 2nd and 3rd body segments fused into a broad plate ..... Glomerida

6. Head without ocelli, anteriorly produced into a beak or rostrum. Body densely hairy (pilose), thin, long with large number of segments .... Siphonophorida
— Head smooth, rounded, without beak or rostrum, ocelli normally present. Body smooth 7
7. Body arched, with 26-30 segments without ozopores, metaterga with keels 3+3 macrochaetae, epiproct with spinnerets .... Chordeumatida
— Body cylindrical, with more than 30 segments, metaterga without keels, no macrochaetae, epiproct with simple spine, no spinnerets 8
8. 1 or 2 big ocelli on each side of head, pleurotergites with middorsal suture .... Stemmiulida
— Several small ocelli, ocular fields triangular, reniform or oval, segmental sclerites fused into a complete ring (monozoneate) 9
9. Head with a median clypeal suture, ocular fields rounded or oval ..... Spirobolida
— Head with occipital suture, ocular fields triangular or reniform 10
10. Large millipedes, head with occipital suture, stipites of the gnathochilarium separated by a large mentum ..... Spirostreptida
— Small millipedes, body up to 1.5 cm long, stipites of the gnathochilarium meeting in midline, mentum small transverse plate or 2 plates at the bases of the stipites ..... Julida

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